March 7, 2005

Labstracts

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News from the Naval Research Laboratory, Washington DC

Discovery points to new class of astronomical objects

Astronomers detect powerful bursting radio source

Sweet Briar College professor, students, and NRL researchers lay groundwork for breakthrough

NRL, Sweet Briar College, NRAO
Press Release

Astronomers at Sweet Briar College and NRL have detected a powerful new bursting radio source whose unique properties suggest the discovery of a new class of astronomical objects. The researchers have monitored the center of the Milky Way Galaxy for several years and revealed their findings in the March 3, 2005 edition of the journal *Nature*.

Principal investigator, **Dr**. **Scott Hyman**, professor of physics at Sweet Briar College, said the discovery came after analyzing some additional observations from 2002 provided by researchers at Northwestern University. "We hit the jackpot!" Hyman said referring to the observations. "An image of the Galactic center, made by collecting radio waves of about one-meter in wavelength, revealed multiple bursts from the source during a seven-hour period from September 30 to October 1, 2002 — five bursts, in fact, and repeating at remarkably constant intervals."

Dr. Hyman, four Sweet Briar students, and his NRL collaborators, **Drs**. **Namir Kassim** and **Joseph Lazio**, happened upon transient emission from two radio sources while studying the Galactic center in 1998. This prompted the team to propose an ongoing monitoring program using the National Science Foundation's Very Large Array (VLA) radio telescope in New Mexico. The National Radio Astronomy Observatory, which operates the VLA, approved the program. The data collected, laid the groundwork for the detection of the new radio source.

"Amazingly, even though the sky is known to be full of transient objects emitting at X- and gamma-ray wavelengths," NRL astronomer Dr. Lazio pointed out, "very little has been done to look for radio bursts, which are often easier for astronomical objects to produce."

The team has monitored the Galactic center for new transient sources and for variability in approximately 250 known sources, but the five bursts from the new radio source, named GCRT J1745-3009, were by far the most powerful seen. The five bursts were of equal brightness, with each lasting about 10 minutes, and occurring every 77 minutes.

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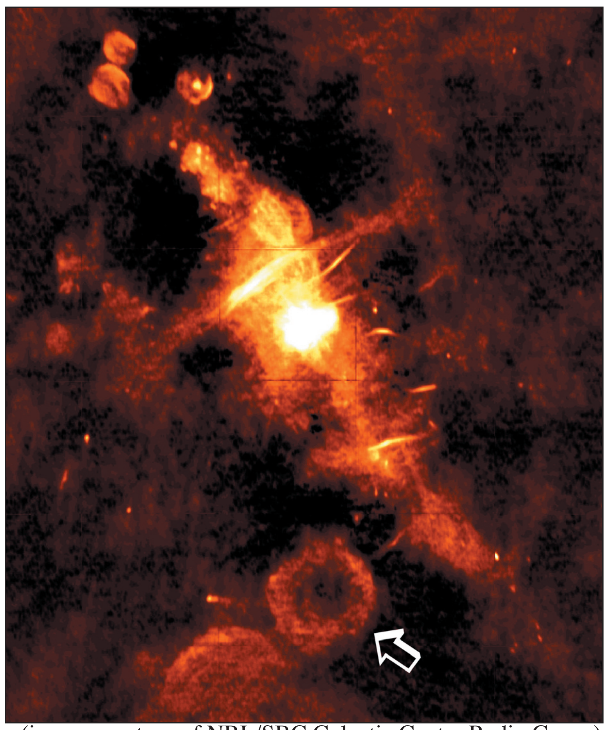

(image courtesy of NRL/SBC Galactic Center Radio Group)

DETECTING POWERFUL RADIO SOURCE — Above is a radio image of the central region of the Milky Way Galaxy. The arrow indicates the same supernova remnant seen in the image on page 4.

NRL people

Dr. Spiro Antiochos receives AAS Hale Prize; Elected to AGU Fellow

Janice Schultz
Public Affairs, Code 1030

Dr. **Spiro Antiochos**, of NRL's Space Science Division, was twice honored in January with distinguished recognitions. First, he was selected as the recipient of the prestigious Hale Prize from the American Astronomical Society (AAS). Shortly thereafter, Dr. Antiochos was notified of his election to Fellow of the American Geophysical Union (AGU).

The Hale Prize is an international award given by the Solar Physics Division of the AAS and is considered the highest honor that can be bestowed on a solar physicist. Named in memory of astronomer **George Ellery Hale**, the prize is given nominally every two years for outstanding contributions over an extended period of time. This year's Hale Prize acknowledges Dr. Antiochos for his work on "the thermodynamics and stability of coronal magnetic fields and for his outstanding public service to the community."

AGU Fellowship recognizes Dr. Antiochos for "outstanding creativity and physical insight in developing theories of solar activity, in particular the breakout model for coronal mass ejections and the thermal nonequilibrium model for prominence formation, and for his leadership in integrating the U.S. solar physics community with the American Geophysical Union." Only 0.1% of the AGU membership is so honored in any given year.

Dr. Antiochos is the head of the Solar Theory Section of the Solar Terrestrial Relationships Branch. His fields of expertise include theoretical solar physics, plasma physics, and computational physics. He is an internationally recognized leader in solar physics whose research is distinguished by the development of innovative models to explain major observational problems. His work relies heavily on magnetohydrodynamic theory and state-of-the-art numerical simulation. Dr. Antio-

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Detection of powerful radio source

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The source of the bursts is transient Dr. Hyman noted. "It has not been detected since 2002 nor is it present on earlier images."

Although the exact nature of the object remains a mystery, the team members currently believe that GCRT J1745-3009 is either the first member of a new class of objects or an unknown mode of activity of a known source class.

One important clue to understanding the origin of the radio bursts is that the emission appears to be "coherent," Dr. Hyman said. "There are very few classes of coherent emitters in the universe. Natural astronomical masers — the analog of laser emission at microwave wavelengths — are one class of coherent sources, but these emit in specific wavelengths. In contrast, the new transient's bursts were detected over a relatively large bandwidth."

In addition to these intriguing properties, NRL astronomer **Dr**. **Paul Ray** and colleague **Dr**. **Craig Markwardt**, of NASA's Goddard Space Flight Center, have searched the source for X-ray emission, but have not found any convincing evidence. "The non-detection of X-ray emission is intriguing," Dr. Ray said. "Many sources that emit transient X-ray flares, such as black hole binary star systems, also have associated radio emission. If upon further observations, X-ray emission is definitively detected or ruled out, this will be a significant help in understanding the nature of this remarkable source."

"Needless to say, the discovery of these transients has been very exciting for our students," Dr. Hyman added. Participating in this research program has inspired at least two of Hyman's students, **Jennifer Neureuther** and **Mariana Lazarova**, to pursue graduate studies in astronomy.

This project was supported at Sweet Briar College by funding from Research Corporation and the Jeffress Foundation. Basic research in radio astronomy at NRL is supported by the Office of Naval Research.

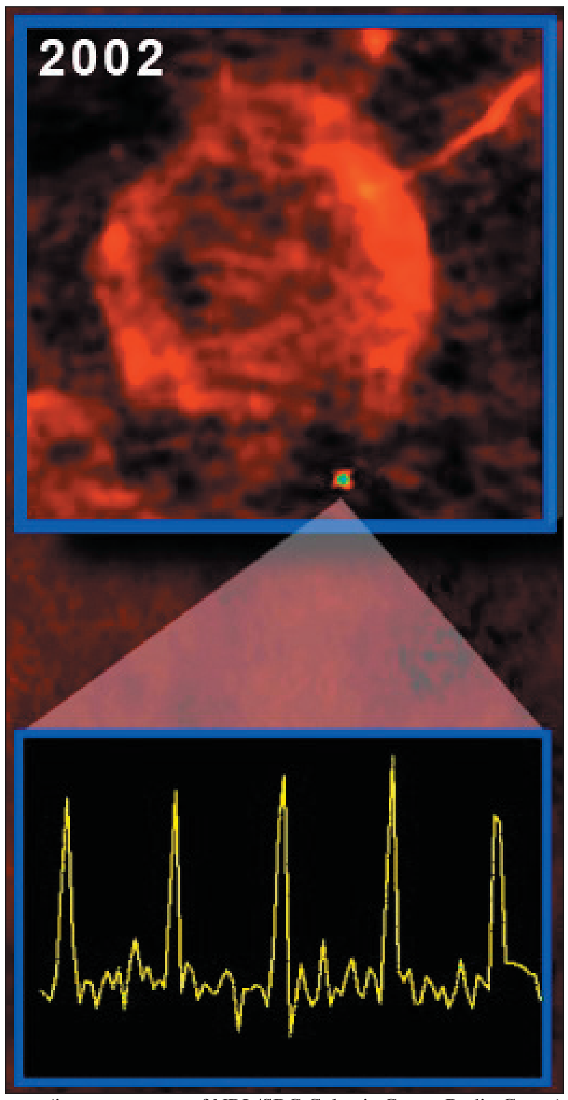
Further research

Dr. Hyman and his NRL colleagues plan to continue monitoring the Galactic center and search for the source again with the VLA and other X-ray and radio telescopes. They are also developing (with **Dr**. **Kent Wood** of NRL) a model that attempts to account for the radio bursts as a new type of outburst from a class of sources known as "magnetars."

NRL is also contributing to an effort to build the world's largest and most sensitive low-frequency telescope, called the Long Wavelength Array (LWA), which may revolutionize future searches for other radio transient sources. Current plans call for the LWA, which is being developed by the University of New Mexico-led Southwest Consortium, to be sited in New Mexico, not far from the VLA.

"One of the key advantages of observing at long radio wavelengths," explained NRL astronomer Dr. Kassim, "is that the field-of-view is so large that a single observation can efficiently detect transient phenomena over a large region."

"When completed, the LWA may uncover hundreds of previously unknown radio transients, some of which may be examples of Jupiter-like planets orbiting other stars," Dr. Kassim added. Jupiter is the most famous example of a nearby radio transient. ◆



(image courtesy of NRL/SBC Galactic Center Radio Group)

POWERFUL RADIO SOURCE DETECTED — A new radio source located below a large expanding ring of debris from a supernova remnant. The plot below is a radio light curve of the five detected bursts occurring every 77 minutes.

NRL people

Dr. Antiochos honored with distinguished recognitions

Continued from bottom of page 3.

A cofounder of coronal loop theory, Dr. Antiochos developed the first numerical model of a coronal loop. He performed the original analytic and numerical modeling of chromospheric evaporation, which showed how coronal loops obtain their mass. It is the basis for all dynamic loop models. He has also made fundamental contributions to the theory of dynamic transition regions in loops, both for quiet Sun and for flares. One of his most important contributions is his model of cool loops to explain the structure of the lower transition region, a model that has inspired a great deal of observational research.

One of the long-standing puzzles in solar physics is the frequent appearance of cool plasma in the midst of the hot corona. Quiescent prominences and filaments are the most common manifestations of this phenomenon, but SOHO and TRACE observations demonstrate that it occurs in a variety of forms and on a variety of time scales. Dr. Antiochos' work has led the field on this problem and has spawned a host of new observational and theoretical research. His thermal nonequilibrium model provides a simple and convincing explanation for both the formation and the recently discovered dynamics of prominence condensations. These results are the culmination of a long history of work on thermal instability and on active prominences, which has advanced the understanding of coronal condensations and prominence formation to a new level.

The structure of the magnetic field that supports prominence material against gravity has been a question that solar physicists have wrestled with for decades. This issue is at the heart of understanding solar activity, because filament channel magnetic fields are widely believed to provide the free energy that powers flares and coronal mass ejections (CMEs). In a seminal paper, Dr. Antiochos showed how magnetic shear in a 3D bipolar geometry can account for the mass support and many other observed features of prominences. This forms the basis for much of the present research on prominence structure and eruption.

In another seminal contribution, Dr. Antiochos developed a "breakout" model for the initiation of coronal mass ejections. It is now recognized that CMEs are the main driver of space disturbances at Earth and are, therefore, the subject of intense investigation by both the solar and space/geophysics communities. The main obstacle in understanding CMEs is the large energy required to accelerate the erupting plasma and open the coronal magnetic field out to the heliosphere. While this problem has been actively studied by many groups throughout the world, Dr. Antiochos' key insight was that magnetic reconnection between neighboring flux systems allows stressed low-lying magnetic field to expand outward explosively while overlying, unstressed field remains closed. The breakout model has enormous implications for predicting space weather, a major national and international thrust. The model is a direct result of Dr. Antiochos' fundamental work on current sheet formation and magnetic reconnection, work that is now finding application in laboratory plasmas, as well.

Dr. Antiochos credits these advances to his collaborations at NRL, noting, "Whatever successes I may have had are, in large part, due to my

(See *Dr. Antiochos honored*, p. 5)